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## SONG VARIATION IN MAINE SONG SPARROWS

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THE Song Sparrow (*Melospiza melodia*) is a very common and widely distributed bird, and its songs are rapid, complex, and highly variable. Its life history and behavior are well known (Nice, 1937, 1943), and much has been written about its songs. Most past studies of the songs of this bird (Wheeler and Nichols, 1924; Nice, 1943; Saunders, 1951) have been based on auditory impressions; Brand (1935) analyzed the song recorded on sound film, and Mulligan (1963) presented a description of the songs of some California birds based on the audiospectrographic analysis of tape-recorded songs. The present paper is based on an analysis similar to that of Mulligan.

The purpose of this paper is to present an account of the variations in the songs of a local population, based on extensive recording over a period of several years. The variations found have raised a number of questions regarding song acquisition in the individual bird, the species-specific features of the songs, the ability of a Song Sparrow to recognize songs of the species or of particular individuals, and the role of song in the biology and evolution of the species; studies on these questions are currently under way and will be reported later.

## METHODS

*The study area.*—The study area (Fig. 1) is located on Hog Island, in Muscongus Bay, Lincoln Co., Maine, and the adjacent mainland; it consists of about 40 acres, 30 on Hog Island and 10 on the mainland.

The Hog Island portion of this area consists of the Audubon Peninsula, located at the north end of the island; the buildings of the Audubon Camp of Maine are located at the north end of this peninsula. South of the buildings the peninsula was originally covered with a rather dense spruce forest, but a hurricane in September 1954, blew down nearly all the trees in a portion of the center of the peninsula, and quite a few trees in the southern part of the peninsula. The blown-down trees were cleared from the central blowdown area in 1955, but relatively little clearing has been done in the southern part of the peninsula. Since 1955 the central blowdown area (hereafter referred to as the Blowdown; see Fig. 1) has grown up in ferns, berry bushes, and small trees. Prior to the 1954 hurricane about 6 to 8 pairs of Song Sparrows nested on the peninsula each year; since the hurricane the nesting population has been 12 to 15 pairs each year.

The mainland portion of the study area (hereafter referred to as the Farm) is located across a channel of Muscongus Bay from the northern tip of the Audubon Peninsula. It is largely an open field bordered by a fairly dense second-growth woods; there are numerous trees and shrubs around the farm buildings. The field slopes from the farm buildings down to the bay, and about halfway down the hill, adjacent to the woods on the northeast side of the field, is a pond about 70 feet in diameter that was constructed in 1951. The field is kept in grass and weeds by mowing every few years, and has changed very little during the period of this study; six to ten pairs of Song Sparrows nest in this area each year.

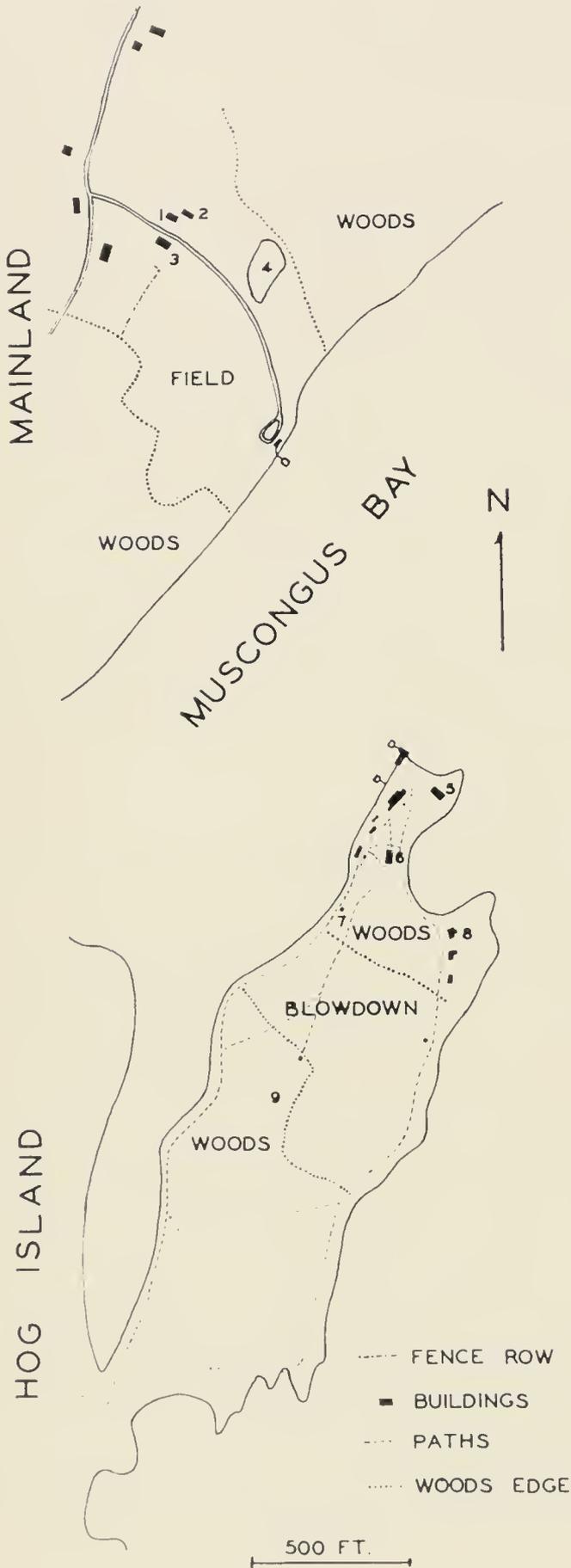


FIG. 1. Map of the Maine study area (the Audubon Camp of Maine), made from an aerial photograph taken in 1940; shorelines are at high tide. Numbers of buildings or areas 1, farmhouse; 2, north barn; 3, south barn; 4, pond; 5, Fish House; 6, Porthole; 7, Assistants' cabin; 8, First Aid Station; 9, bog. The Farm, on the mainland, includes the field and the woods bordering the field, from the numbered buildings to the Bay; the peninsula of Hog Island is the Audubon Peninsula.

TABLE 1  
SUMMARY OF THE MAINE SONG SPARROW RECORDINGS STUDIED

	Study area			Bay Islands	Distance from study area on mainland			Total
	Hog Is.	Farm	Total		1-7 miles	8-15 miles	25-112 miles	
Birds	51	26	77	21	12	5	5	120
Recordings	481	105	586	29	19	5	5	644
Songs	4,997	1,648	6,645	279	208	61	19	7,212

*Recording techniques.*—The recordings from 1953 through 1961 were made with a Magnemite Model 610-E recorder, using a Brush BK-106 microphone mounted in a hand-held 24-inch parabolic reflector; the recordings in 1962 and 1963 were made with a Nagra III recorder, using a D-33 American microphone mounted in the reflector. All recordings were made at a tape speed of 15 ips.

The recordings made during the first few years of this study were made as opportunity offered; no attempt was made to stimulate the birds to sing. During the seasons from 1956 through 1961 occasional playbacks of Song Sparrow songs were made to birds on their nesting territories, and it was very soon discovered that such playbacks were highly effective in stimulating the birds to sing. The use of playbacks during these seasons was rather sporadic, due to difficulties with the playback equipment. In 1962 and 1963, when the Nagra recorder (which had a built-in speaker) was used, playbacks were frequently used to stimulate singing.

Playbacks of a Song Sparrow song to a Song Sparrow on its nesting territory usually produced a very characteristic reaction, although the strength of this reaction varied somewhat at different times and with different birds. In many cases, if the bird was not in evidence before the playback, the first or second song would bring it out, usually to a point near the speaker. The bird usually hopped and flew about a great deal, often coming quite close to the speaker, and it generally began to sing. In some cases it crouched low, holding its wings slightly above the horizontal and vibrating them, and it occasionally uttered a very soft song; this soft song was usually uttered for only a few seconds, after which the bird began singing one of its usual (louder) songs.

When a bird was found singing fairly consistently, a series of songs (usually a minute or two) was recorded; if the bird continued singing songs of the same pattern, the recording was stopped until the bird changed to another pattern; a series of this song was then recorded, and this process continued until the bird stopped singing. On many occasions during a recording (particularly in 1962 and 1963), if a bird stopped singing and flew to a distant point, a playback of its last-recorded song would result in the bird flying back to the vicinity of the recorder and beginning to sing again.

The number, song content, and source of the Maine Song Sparrow recordings on which this paper is based are shown in Table 1. All recordings were made by the writer, between early June and the middle of August.

*Definition of terms.*—The term *song*, in speaking of Song Sparrow vocalizations, refers to those vocalizations that are more or less prolonged, and normally consist of a varied series of notes and phrases. It includes Nos.

10 ("warbler"), 11 ("advertising song"), 12 ("flight song"), and 13 ("female song"), in Mrs. Nice's list (1943:274) of the 21 chief vocalizations of the Song Sparrow. The other vocalizations in this list, which are either single notes or short series of similar notes, might be collectively referred to as *call notes*. Since I have no recordings from the Maine birds that appear to represent what Mrs. Nice calls the warble and flight song, and since all the very soft songs recorded were of the same patterns as the louder advertising songs, my comments on song variation in the Maine birds refer only to variation in the advertising songs (Category No. 11 of Mrs. Nice's list).

A song is made up of notes and phrases; a *note* is a single sound, and a *phrase* is a group of one or more notes. The silent intervals between phrases are generally longer than those between the notes in a phrase. If a given note or phrase is uttered two or more times in succession at rates of 6 to 25 per second, the utterance is called a *trill*. The term *buzz* is used for sounds that appear buzzy to our ear, that is, sounds consisting of separate and similar notes uttered at rates greater than about 40 per second, or a note that fluctuates in pitch at a rate greater than about 40 per second.

A *song pattern* is a particular sequence of phrases *and the minor variations in this sequence*. Armstrong (1963) considers this term ambiguous, and uses the term "song-versions"; other writers use still other terms, such as "song types," "motifs," "sentences," or simply "different songs."

The song patterns of the Maine birds studied may be classified into two general types on the basis of the number and spacing of the introductory phrases: *Type 1*, with 1 to 5 (usually 2 to 4, rarely 6) introductory phrases that are relatively evenly spaced, or with the increase in rate gradual through the series (Figs. 2-5, 7, 9 A-C, and 10); and *Type 2*, with 5 to 20 introductory phrases, the first two or three of which are usually noticeably slower than the rest (Figs. 6, 8, and 9 D). The distinction between these two types of song patterns is not sharp, and the classification of a few patterns is somewhat arbitrary.

*The identification of individual birds.*—The songs in a given recording were all sung by the same bird, which was nearly always kept in view during the recording. Different recordings made in a given area during the nesting season, of a bird on its nesting territory, were assumed to be of the same bird: in most cases this assumption was supported by the same song patterns occurring in different recordings. Since none of the birds recorded was color-banded or otherwise marked for individual recognition, and since recognition was based solely on song pattern and territory, it is possible that errors have been made in the identification of some birds. Such errors are probably at a minimum, and it is believed that the vast majority of the birds were correctly identified.

*Song analyses.*—The recorded songs were analyzed with a Vibralyzer sound spectrograph, but it was not necessary to graph every song in a recording to be sure of its structure. A Song Sparrow generally sings a series of songs of one pattern before changing to another, and the recordings usually contained series of similar songs; after graphing the first song in a series, it was usually possible to determine the structure of the remaining songs in the series by listening to the recording played at a reduced tape speed. Songs that appeared a little different at this reduced speed were graphed to be sure of their structure.

In recording the structure of a song, the various notes and phrases were designated by letters; different letters were used for different types of notes or phrases. Both capital and lower case letters were used, sometimes with a superscript number, in order to have a different designation for each type of note or phrase. *I* (with a superscript number) was used for introductory phrases, and *T* (with a superscript number) was used for trill phrases. If a given phrase was uttered two or more times in succession, the number uttered was indicated by a subscript number. For example, the song shown in Fig. 2 A was recorded as  $I^8 I_2^{99} a D T_{10}^{63} i m x^0 E^3 N$ .

Individual birds were designated by two capital letters, and their different song patterns by number; for example, pattern 4 of bird FH was designated as pattern FH-4. Each variation of a given pattern was designated by a letter, and sometimes one or two subscript numbers; the letter represented the particular sequence of phrases in the variation; one subscript number represented the number of trill phrases present (in a Type 1 song pattern) or the number of introductory phrases present (in a Type 2 pattern); two subscript numbers separated by a comma represented the number of introductory and trill phrases, respectively (in a Type 2 pattern that had a trill beyond the introductory phrases). Thus each song could be designated, more briefly than with a series of letters for the different phrases, as a particular variation of a particular pattern.

For example, the variation of pattern FH-4 (a Type 1 pattern) shown in Fig. 2 A was represented as FH-4L<sub>10</sub> (the bracketed sequence immediately above the graph): L represented the sequence of phrases  $I^8 I_2^{99} a D T_{10}^{63} i m x^0 E^3 N$ , and 10 the number of trill ( $T^{63}$ ) phrases. The variation of pattern WT-8 (a Type 2 pattern) shown in Fig. 6 A was represented as WT-8C<sub>6</sub>; C represented the phrase sequence  $I^{21} B c E c Z^3$ , and 6 the number of introductory ( $I^{21}$ ) phrases. The variation of pattern IS-5 (a Type 2 pattern with a trill beyond the introductory phrases) shown in Fig. 6 C was designated as IS-5C<sub>6, 10</sub>; C represented the phrase sequence  $I^4 c^0 E^2 T^{22} c a E c Z^1$ , 6 the number of introductory ( $I^4$ ) phrases, and 10 the number of trill ( $T^{22}$ ) phrases.

The graphs in this paper contain some examples of a given phrase (represented by a particular letter, or letter and superscript number) in different songs of the same bird (especially Figs. 2–5) and in the songs of different

TABLE 2  
DATA ON THE INTRODUCTORY PHRASES IN MAINE SONG PATTERNS

Area		Maximum number of introductory phrases		Number of song patterns <sup>†</sup> with		
		Range	Average*	1 Type of 1	2 Types of 1	3 Types of 1
Study area	Hog Island	1-13	3.75 ± 0.12	244	41	6
	Farm	2-20	3.86 ± 0.21	130	28	2
Bay Islands		1-13	4.18 ± 0.42	41	8	0
Distance from study area on mainland	1-7 miles	2-9	3.50 ± 0.32	27	3	0
	8-15 miles	2-10	4.56 ± 1.07	9	0	0
	25-112 miles	2-4	2.80 ± 0.37	5	0	0
All Maine patterns		1-20	3.82 ± 0.10	456	80	8

\* Averages are given plus or minus the standard error.

<sup>†</sup> The numbers of song patterns in this and other tables do not take into consideration cases of a given pattern being sung by two or more birds.

birds (especially Figs. 7-10), and illustrate some of the variation found in individual phrases. Because the phrases often varied slightly in different songs, it is perhaps a matter of opinion where the line is drawn between what is one type of phrase and what is another. The data in this paper regarding the number of types of phrases in different songs or in the vocabularies of different birds thus have a subjective basis, but are at least indicative of the existing variation.

The particular song (or songs) from which each graph in this paper was made is indicated by a hyphenated number; the number before the hyphen is the number of the recording, and the number after the hyphen is the number of the song in the recording.

#### CHARACTERISTICS OF THE SONGS OF THE MAINE BIRDS

*The general character of the songs.*—Most songs began with two or more similar phrases, the *introductory phrases*; the remaining phrases varied considerably in different songs. Each bird had a vocabulary of many different notes and phrases, and these were variously combined to produce different songs. The songs of a given bird that began with the same type (or types) of introductory phrases, followed by approximately the same sequence of other phrases, were said to represent a given song pattern. A bird usually sang songs of a given pattern for a time, then changed to another pattern; rarely, it would sing songs of two patterns more or less alternately.

TABLE 3  
SUMMARY OF THE CHARACTERS OF THE INTRODUCTORY PHRASES IN MAINE SONGS

Character		Type 1 songs	Type 2 songs	All songs
First introd. phrase	Length (sec.)	Range 0.13-0.51 Avg.* 0.341 ± 0.005	0.23-0.50 0.311 ± 0.010	0.13-0.51 0.336 ± 0.004
	Rate†	Range 1.96-7.69 Avg. 2.936	2.00-4.35 3.220	1.96-7.69 2.977
Last introd. phrase	Length (sec.)	Range 0.13-0.64 Avg.* 0.319 ± 0.003	0.08-0.20 0.121 ± 0.004	0.08-0.64 0.292 ± 0.004
	Rate	Range 1.56-7.69 Avg. 3.137	5.00-12.50 8.236	1.56-12.50 3.419
Ratio, first I/last I	Range	0.38-2.13	1.77-3.59	0.38-3.59
	Avg.	1.069	2.558	1.148

\* Averages of phrase length are given plus or minus the standard error.

† Rate is given as the number of phrases per second.

The songs included both musical and nonmusical notes. The musical notes varied in length from about 0.04 to 0.25 second (rarely longer), they were usually steady in pitch, and they contained a dominant frequency (usually the fundamental) and often harmonics. The nonmusical notes were usually short (up to 0.03 second in length) and very abruptly slurred, or buzzy. The buzzes were of three principal types; those designated as *Z* buzzes had a modulation frequency of 42 to 100 per second (average,  $54.3 \pm 0.9$ ), and were usually 0.2 to 0.5 second in length; other buzzes had a modulation frequency of 145 to 165 per second (e.g., the first part of the *D* phrase, Fig. 2), and still others 300 to 335 per second (e.g., the last note in *I*<sup>8</sup>, Fig. 2 B), and these were usually from 0.05 to 0.25 second in length. Most songs contained some buzzes, but their location in the song varied.

Most songs contained a trill following the introductory phrases; when a trill was present, its location in the song varied.

*Pattern type.*—The majority of the Maine song patterns, 473 (86.95%) of the 544, were of Type 1, that is, they began with 1 to 5 (usually 2 to 4) introductory phrases that were relatively evenly spaced (Table 5); 71 (13.05%) of the patterns were of Type 2, that is, they began with 5 to 20 introductory phrases, the first two or three of which were usually noticeably slower than the rest.

*The introductory phrases.*—Saunders (1951) and Nice (1943) state that most

introductory phrases in Song Sparrow songs are one-noted, with a few two-noted: the spectrograms of Mulligan (1963) show introductory phrases containing from one to three notes. The introductory phrases in the Maine songs studied contained from one to five (average,  $2.5 \pm 0.1$ ) notes; about three-fourths of the introductory phrases contained two or three notes. In many of the introductory phrases containing two to four notes, one or two of these notes were very short and weak: such phrases would appear one- or two-noted to the ear.

Four of the 7,212 songs studied began with a very short note that normally occurred in the middle of the song:

- FH-5M—1 of 44 FH-5 songs began with an  $x$  note
- FH-7H<sub>8</sub>—1 of 34 FH-7 songs began with an  $i$  note
- PL-2B—1 of 11 PL-2 songs began with a  $c^0$  note
- PR-4C<sub>10</sub>—1 of 50 PR-4 songs began with a  $c$  note

These notes ( $x$ ,  $i$ ,  $c^0$ , and  $c$ ) are looked upon as accidental utterances in these songs, and are not treated as true introductory phrases.

The number of introductory phrases in a song varied from 1 to 20 (Table 2). It seldom varied in a given pattern more than a phrase or two in Type 1 patterns, or more than three or four phrases in Type 2 patterns; the figures in Table 2 are based on the maximum number found in each pattern.

The introductory phrases of most (83.82%) song patterns were all of the same type, but in a few patterns (14.71%) there were two types of introductory phrases (Figs. 2, 7 A, 9 A–C, and 10 A–C), and rarely (in 1.47% of the patterns) there were three types of introductory phrases (Table 2).

Table 3 contains data on the lengths of the first and last introductory phrases; the introductory phrases increased in rate through the series in most patterns. The ratio between the lengths of the first and last introductory phrases varied from 0.38 to 3.59, and for all patterns averaged 1.15: this ratio was greater (indicating a greater increase in phrase rate) in Type 2 than in Type 1 songs. The first introductory phrases were uttered at rates of 1.96 to 7.69 per second (average, 2.98 per second), and were faster in Type 2 (averaging 3.22 per second) than in Type 1 (averaging 2.94 per second) songs. The final introductory phrases were uttered at rates of 1.56 to 12.50 per second (average, 3.42 per second), and were much faster in Type 2 than in Type 1 songs (averaging 8.24 per second in Type 2, 3.14 per second in Type 1). Most (88.41%) of the Type 2 song patterns had the final introductory phrases uttered faster than six per second, or fast enough to be described as a trill.

TABLE 4  
DATA ON THE TRILL PHRASES IN MAINE SONG PATTERNS

Area		Maximum no. of trill phrases		Trill phrase length (in seconds)		Trill phrases per second	
		Range	Average*	Range	Average*	Range	Average
Study area	Hog Is.	3-26	9.89 ± 0.12	0.046-0.192	0.078 ± 0.002	5.2-21.7	12.83
	Farm	4-16	9.09 ± 0.25	0.048-0.180	0.083 ± 0.002	5.6-20.8	11.99
Bay Islands		5-17	9.00 ± 0.47	0.043-0.150	0.078 ± 0.005	6.7-23.3	12.80
Distance from study area on mainland	1-7 miles	3-12	7.63 ± 0.52	0.057-0.172	0.091 ± 0.006	5.8-17.5	11.01
	8-15 miles	4-15	8.57 ± 1.36	0.060-0.143	0.095 ± 0.014	7.0-16.7	10.57
	25-112 miles	5-11	7.20 ± 1.07	0.068-0.117	0.095 ± 0.008	8.5-14.7	10.48
All Maine patterns		3-26	9.40 ± 0.14	0.043-0.192	0.081 ± 0.001	5.2-23.3	12.36

\* Averages are given plus or minus the standard error.

*The trills.*<sup>1</sup>—Each bird usually had several different types of trill phrases in its vocabulary (see Table 7), and a given trill phrase often appeared in more than one of its song patterns. If a trill phrase appeared as a single phrase only, it was not called a trill; it was called a trill only if it appeared at least twice in succession in at least some variations of the pattern.

Only one instance (bird BD) was found of a bird using a particular phrase as an introductory phrase in one pattern ( $I^4$  in BD-7; see Fig. 9) and as a trill phrase in another pattern ( $T^{35}$  in BD-9;  $I^4$  is the same phrase as  $T^{35}$ ; see Fig. 11 BB). No song pattern was found in which the trill phrases were similar to the introductory phrases in that pattern, although most (88.41%) of the Type 2 patterns had the final introductory phrases uttered fast enough to be described as a trill.

The occurrence of a trill in the Maine song patterns is shown in Table 5. Trills occurred much more commonly in Type 1 patterns than in Type 2 patterns: 387 (81.82%) of the Type 1 patterns contained a trill, while only 23 (32.39%) of the Type 2 patterns contained a trill. A trill beyond the introductory phrases was present in at least some songs of 410 patterns (75.37%) and absent in 134 patterns (24.63%); in 322 (78.54%) of the 410 patterns with a trill, the trill was present in all songs of the pattern, while in the remaining 88 (21.46%) only some of the variations contained the trill.

There were two trills beyond the introductory phrases in 15 (2.76%) of the song patterns; all but one of these were of Type 1. In 11 of these 15 patterns the two trills occurred in the same song; in the other 4 they occurred

<sup>1</sup> This discussion of trills applies only to phrases beyond the introductory phrases that were uttered at rates of 6 to 25 per second.

TABLE 5  
SOME CHARACTERISTICS OF MAINE SONG PATTERNS

		Number of patterns from						Total	
		Study area		Bay Islands	Distance from study area on mainland				
		Hog Is.	Farm		1-7 miles	8-15 miles	25-112 miles		
Song pattern type		Type 1	255	141	38	27	7	5	473
		Type 2	36	19	11	3	2	0	71
		Total	291	160	49	30	9	5	544
Occurrence of a trill beyond intro- ductory phrases	Trill present	In all songs	167	104	23	19	4	5	322
		In some songs	54	21	6	4	3	0	88
	Total	221	125	29	23	7	5	410	
		Trill absent	70	35	20	7	2	0	134
Location of trill*	Immediately following I		51	20	2	2	0	1	76
	1-3 phrases after I		93	49	9	10	2	4	167
	Later in song		84	58	19	11	6	0	178
Occurrence of Z buzzes	Z present	In all songs	135	88	35	15	4	2	279
		In some songs	96	29	6	6	3	1	141
	Total	228	115	40	19	7	3	412	
		Z absent	63	45	9	11	2	2	132
With two Z buzzes			13	6	3	4	0	0	26

\* In 11 patterns (7 from Hog Is., 2 from the Farm, 1 from the Bay Islands, and 1 8-15 miles from the study area on the mainland) the location of the trill varied in different variations of the pattern.

in different variations of the pattern. In two other patterns, some songs contained a trill consisting of two slightly different types of trill phrases (Fig. 4 C).

Table 4 contains data on the number, length, and rate of the trill phrases in the Maine song patterns. The number of trill phrases in patterns containing a trill varied from 0 (variations lacking the trill) to 26. The phrase rate in the trills varied from 5.2 (the slowest rate of a phrase type which, in different patterns, averaged more than 6 per second) to 23.3 phrases per second. The trill was usually between 0.5 and 1.0 second in length, and the number of phrases in it was generally inversely proportional to their length.

The location of a trill beyond the introductory phrases varied in different patterns, and in 11 (2.68%) of the 410 patterns containing a trill the location varied in different variations of the pattern. The trill was immediately after

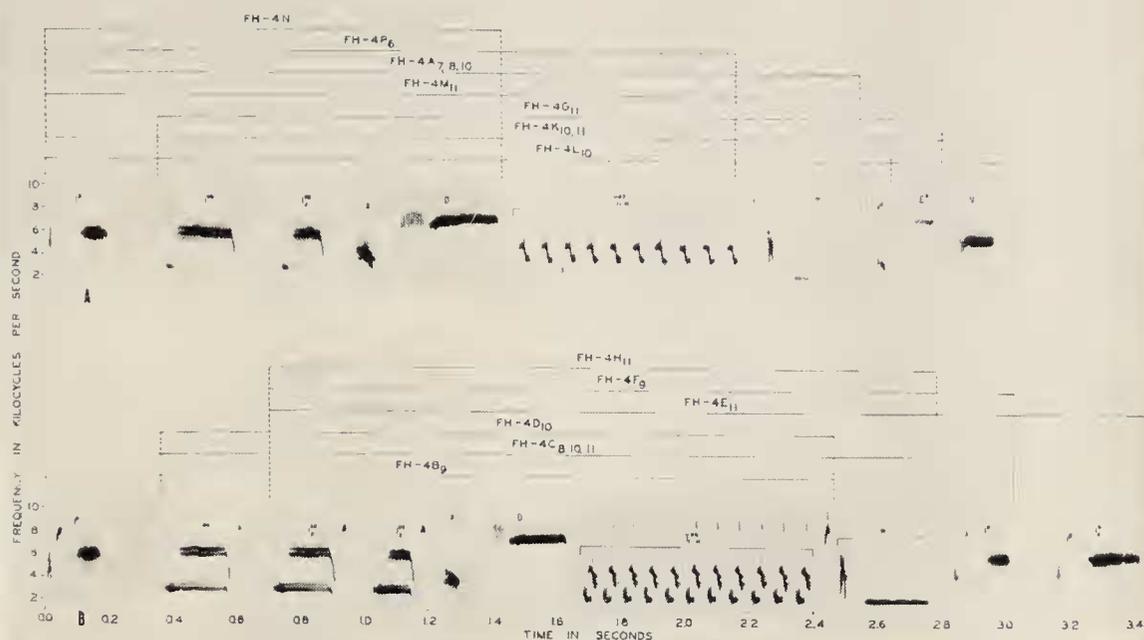


FIG. 2. Variations in the songs of pattern FH-4 (A from 2161-3, B from 1538B-3 and 1506B-24).

the introductory phrases in 76 (18.54%) of the 410 patterns, from one to three phrases after the trill in 167 (40.73%), and later in the song in 178 (43.41%) patterns (Table 5).

*The Z buzzes.*—Most song patterns contained what have been termed *Z* buzzes, which had modulation frequencies of 42 to 100 per second. Table 5 shows the incidence of these buzzes; they occurred in 412 (75.74%) of the 544 patterns.

*Song length.*—Some information on song length is indicated in the figures. There was a great deal of variation in the length of the Maine songs, most of it due to variation within patterns. A Song Sparrow starting a song may stop anywhere along a given sequence of phrases, even after the first introductory phrase. Most songs were at least 2 seconds in length, and the majority were between 2.5 and 3.0 seconds in length; some were as long as 3.5 seconds, and a few were as long as 4.0 seconds.

*Singing rate.*—Singing rate was calculated from measurements of the time from the beginning of one song to the beginning of the next; this interval is called the cadence by Reynard (1963). Measurements of 206 such intervals in normal song, from 16 birds, selected at random, varied from 6.0 to 22.5 seconds, and averaged  $11.44 \pm 0.20$  seconds (corresponding to a rate of

TABLE 6  
INCIDENCE OF THE MOST COMMON PHRASES IN THE SONGS OF THE MAINE BIRDS

Phrase	Figures	Number of song patterns from					
		Study area			Distance from study area		
		Hog. Is.	Farm	Total	8 miles or less	8-15 miles	25-112 miles
<i>I</i> <sup>1</sup>	6, 9, 10	9	13	22	2	0	0
<i>I</i> <sup>10</sup>	9, 10	10	13	23	4	0	0
<i>I</i> <sup>26</sup>	6, 9	12	14	26	7	2	0
<i>I</i> <sup>29</sup>	4, 5	20	11	31	3	1	0
<i>I</i> <sup>36</sup>		15	9	24	2	0	0
<i>I</i> <sup>72</sup>	4	7	13	20	0	1	0
<i>I</i> <sup>98</sup>	6	13	10	23	3	0	0
<i>I</i> <sup>99</sup>	2, 8	16	8	24	1	0	0
<i>T</i> <sup>1</sup>	5, 7	33	14	47	7	2	0
<i>T</i> <sup>3</sup>	7	21	11	32	1	0	0
<i>T</i> <sup>5</sup>	4, 10	27	21	48	9	1	0
<i>T</i> <sup>6</sup>	9	16	10	26	1	0	0
<i>T</i> <sup>11</sup>	10, 11	10	11	21	1	1	0
<i>a</i>	2-6, 9	38	23	61	20	2	2
<i>A</i>	12	33	23	56	14	0	0
<i>b</i>	3-5, 7, 10	38	26	64	17	1	0
<i>B</i>	3-7, 9, 10	36	22	59	7	1	0
<i>c</i> <sup>*</sup>	2-10	51	26	77	33	5	4
<i>c</i> <sup>0</sup>	6	29	16	45	10	3	1
<i>E</i> <sup>2</sup>	5-7	29	18	47	15	2	1
<i>j</i>	3, 4, 6, 8-10	36	24	60	16	2	0
<i>m</i>	2-4, 7	31	17	48	22	1	0
<i>M</i>	6, 9	20	13	33	6	0	0
<i>Z</i> <sup>1</sup>	3, 4, 6, 9, 10	43	21	64	16	2	0
<i>Z</i> <sup>3</sup>	6, 8	29	9	38	10	0	0

\* *c* is the first note of an *m* phrase.

5.2 ± 0.1 songs per minute). This figure corresponds fairly well with the average cadence given by Reynard (1963) of 11.8 seconds.

If a bird was stimulated by playbacks of Song Sparrow songs, its singing rate was significantly higher. Measurements of 215 intervals in such stimulated song, from seven birds, selected at random, varied from 4.5 to 14.0 seconds, and averaged 7.33 ± 0.09 seconds (corresponding to a rate of 8.2 ± 0.1 songs per minute).

*Local variation.*—The bulk of the Maine recordings were made in the study area (see Fig. 1 and Table 1), but some were made on various islands in Muscongus Bay (½ to 8 miles from the study area), and on the mainland 1½ to 112 miles from the study area. The distribution of the 544 patterns is shown in Table 5.

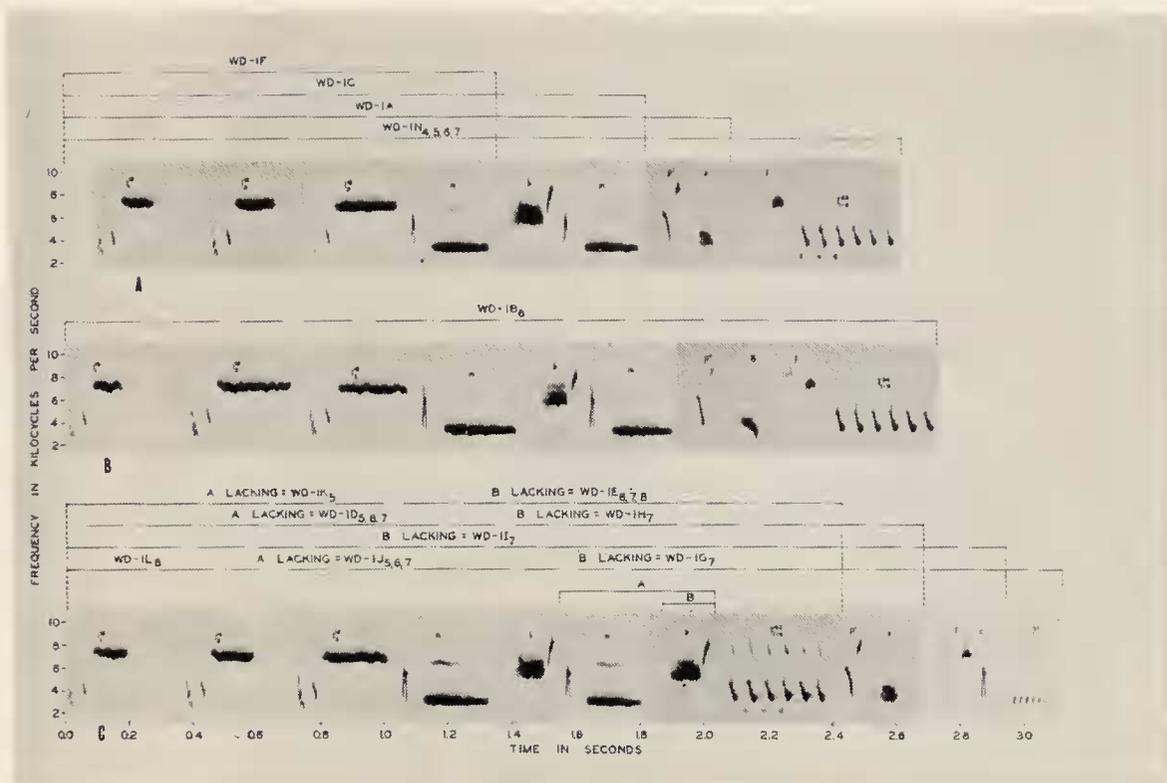


FIG. 3. Variations in the songs of pattern WD-1. The song shown in A (5274-1) was recorded in 1961, that in B (2936-3) was recorded in 1957, and that in C (4232-6) was recorded in 1959. One song in recording 2936 contained an *a* note (as in A and C) rather than a *B* note.

The patterns from different Maine areas differed in various characteristics—in the proportions of the two types of song patterns (Table 5), the number of introductory and trill phrases (Tables 2 and 4), the number of types of introductory phrases in a given pattern (Table 2), in the presence of a trill in the song (Table 5), in the length and rate of the trill (Table 4), in the location of the trill (Table 5), and in the incidence of *Z* buzzes (Table 5), but these differences were for the most part not significant. The phrase rate in the trills was significantly higher in patterns from Hog Island than in those from the Farm area; the maximum number of trill phrases was greater in patterns on the study area than elsewhere in Maine; the trill when present occurred later in the song in relatively more song patterns of birds on the Bay Islands than elsewhere, and in relatively fewer patterns on the study area than elsewhere; and the first introductory phrases of the song were uttered significantly faster in patterns on the mainland portion of the study area than in patterns on Hog Island. Relatively more of the patterns of birds on the Bay Islands (other than Hog Island) lacked a trill, and more of the island patterns were of Type 2, than was the case with patterns of birds elsewhere in Maine.

Table 6 shows the incidence of the most common types of phrases in the song patterns of the Maine birds, both within and outside the study area. For each of these phrases the incidence was less outside the study area than in it, and in general the farther away from the study area one goes, the less common the phrase is.

The two portions of the Maine study area are separated by a channel of Muscongus Bay about 300 yards wide (Fig. 1); a Song Sparrow song can be heard across this channel. The data in Table 6 show that for each phrase listed there is a somewhat different incidence in the two portions of the study area, but these differences are in most cases (all except  $I^1$ ,  $I^{10}$ , and  $I^{72}$ , which occur in the vocabularies of significantly more Farm birds than Hog Island birds) not significant. The island and mainland populations of the study area thus appear to be essentially a single population, as far as the character of the phrases in their songs is concerned.

The data in Table 6 indicate that we have in the Song Sparrow what might be called local dialects, and it suggests that the various notes and phrases of the song are learned by listening to other birds, and that the majority of the birds in the study area were there at the time of their life when the phrases of the song are acquired. Mr. Joseph M. Cadbury, who has banded a number of Song Sparrows on the study area, informs me (in correspondence) that he has a number of records of birds banded as nestlings on the area that have returned as adults.

The songs of a few birds in the study area were such as to suggest that they learned the phrases of their songs somewhere outside the study area. The songs of IN, for example, a bird that nested near the First Aid Station on Hog Island in 1955, 1956, and 1957, contained some unique phrases: five of its six introductory phrase types and three of its four trill phrase types occurred in the songs of no other birds studied. The songs of PA, which nested in the Blowdown in 1960, 1961, and 1962, also contained some unique phrases: four of its eight introductory phrase types and four of its five trill phrase types occurred in the songs of no other birds studied. IN and PA probably hatched and grew up somewhere outside the study area.

#### SONG VARIATION IN INDIVIDUAL BIRDS

*Vocabularies of individual birds.*—The number of different phrases found in the songs of 53 birds recorded in the study area is shown in Table 7: each of these birds was represented in the recordings by either 50 or more songs or by at least six song patterns. The vocabularies of these birds varied from 23 to 53 phrases, and averaged 37.6; since 50 songs may be inadequate to determine a bird's vocabulary, some of these figures may be only a minimum estimate. The vocabularies of the 20 birds represented by 100 or more songs

ranged from 26 to 51 phrases, and averaged 40.9; those of the 10 birds represented by 200 or more songs ranged from 26 to 51 phrases, and averaged 41.2. It thus appears that the birds studied had, on the average, about 40 phrases in their vocabularies.

*Variation within a song pattern.*—Practically every song pattern in the recordings, if represented by two or more songs, showed some variation. For example, there were 18 variations in the 39 songs studied of pattern FH-4 (Fig. 2):

1.	$I^8 I_2^{90} a D T_{10}^{63} i m x^0 E^3 N$	.....	FH-4L <sub>10</sub>
2.	$I^8 I_2^{90} a D T_{10}^{63} i m x^0 E^3$	.....	FH-4K <sub>10</sub>
3.	$I^8 I_2^{90} a D T_{11}^{63} i m x^0 E^3$	.....	FH-4K <sub>11</sub>
4.	$I^8 I_2^{90} a D T_{11}^{63} i m x^0$	.....	FH-4M <sub>11</sub>
5.	$I^8 I_2^{90} a D T_7^{63} i m$	.....	FH-4A <sub>7</sub>
6.	$I^8 I_2^{90} a D T_8^{63} i m$	.....	FH-4A <sub>8</sub>
7.	$I^8 I_2^{90} a D T_{10}^{63} i m$	.....	FH-4A <sub>10</sub>
8.	$I^8 I_2^{90} a D T_6^{63}$	.....	FH-4P <sub>6</sub>
9.	$I^8 I_2^{90} a D$	.....	FH-4N
10.	$I^8 I_3^{90} a D T_9^{63} c^1$	.....	FH-4B <sub>0</sub>
11.	$I_3^{90} a D T_8^{63} i m$	.....	FH-4C <sub>8</sub>
12.	$I_3^{90} a D T_{10}^{63} i m$	.....	FH-4C <sub>10</sub>
13.	$I_3^{90} a D T_{11}^{63} i m$	.....	FH-4C <sub>11</sub>
14.	$I_3^{90} a D T_{10}^{63} c^1$	.....	FH-4D <sub>10</sub>
15.	$I_2^{90} a D T_{11}^{63} i m I_2^8$	.....	FH-4E <sub>11</sub>
16.	$I_2^{90} a D T_9^{63} i m I^8$	.....	FH-4F <sub>9</sub>
17.	$I_2^{90} a D T_{11}^{63} i m$	.....	FH-4H <sub>11</sub>
18.	$I_2^{90} a D T_{11}^{63} i m x^0 E^3$	.....	FH-4G <sub>11</sub>

The songs of FH-4 showed several sorts of variations: (a) in the number of introductory phrases (two or three), (b) in the type of introductory phrases (the first ten of the above variations contained two types of introductory phrases, and the rest only one type—at least at the beginning of the song), (c) in the number of trill ( $T^{63}$ ) phrases (6 to 11), (d) in where along the sequence the song ended (cf. variations 3, 4, and 5), and (e) in the way the song ended (cf. 10 and 11). This pattern was one of the few found in which phrases used by the bird as introductory phrases ( $I^8$ ) also appeared later in the song (variations 15 and 16).

FH had two patterns beginning with  $I^{29}$  phrases, FH-2 and FH-13; these patterns were considered different, even though they began with the same introductory phrases, because the remaining phrases were different (see Fig. 4, C and D). Pattern FH-13 was unusual in that its trill usually contained two types of phrases ( $T^{38}$  and  $T^{48}$ ); the subscript numerals in the pattern designation FH-13A<sub>3-5</sub> refer to the numbers of  $T^{38}$  and  $T^{48}$  phrases, respectively.

The song patterns of FH were sufficiently different that their delimitation presented no problem; in many birds the delimitation of patterns was not as simple. For example, two groups of variations of the songs of BG were very

TABLE 7  
VOCABULARIES AND REPERTOIRES OF A SELECTED GROUP OF MAINE BIRDS

Bird	Loca- tion <sup>1</sup>	Years recorded	No. of record- ings	No. of songs	No. of song pat- terns	No. of song varia- tions	Songs per vari- ation	No. of different phrases in vocabulary				
								I	T	Z	Other	Total
AP	M	61	7	115	8	61	1.885	9	5	3	23	40 <sup>2</sup>
BA	HI	57, 58, 59	28	202	9	178	1.135	10	6	2	25	43
BB	M	61	7	52	5	28	1.857	6	5	2	11	24
BD	HI	56, 58, 59, 60, 61, 62	41	404	10	151	2.675	11	6	3	26	46 <sup>3</sup>
BG	HI	59, 60	9	44	6	23	1.913	6	3	2	13	24
BH	M	62	2	33	6	17	1.941	5	2	3	24	34
BN	M	61	3	52	6	37	1.405	8	3	3	15	29
BT	HI	59, 60, 61	13	80	9	51	1.569	9	5	2	26	42
CB	HI	59, 60, 61, 62	30	269	13	83	3.241	13	6	4	25	48
CF	1-8	60, 61	5	124	9	48	2.583	10	5	3	24	42
CL	HI	58, 59, 60	11	94	12	74	1.270	12	7	3	31	53
CW	HI	56, 57	6	28	6	22	1.273	5	5	4	24	38
DC	HI	58, 59, 60, 61	9	86	7	53	1.623	9	5	3	19	36
DH	HI	62, 63	8	109	8	72	1.514	8	3	2	22	35
EA	BI	61	2	72	6	28	2.571	10	3	5	17	35
EM	BI	58	4	24	7	14	1.714	6	6	2	20	34
FG	HI	57	13	161	6	67	2.403	6	3	1	22	32
FA	HI	62, 63	2	116	11	71	1.634	13	5	3	26	47
FB	HI	63	2	62	8	35	1.771	8	5	4	26	43
FH	HI	55, 56	61	462	13	190	2.432	13	7	4	27	51 <sup>4</sup>
FP	HI	62	6	135	9	65	2.077	10	7	2	22	41
HI	BI	58	1	30	6	16	1.875	5	3	3	19	30 <sup>5</sup>
IN	HI	55, 56, 57	10	201	6	62	3.242	6	4	3	17	30
IS	HI	58, 60, 61, 62	15	251	8	109	2.303	10	5	3	15	33
IV	HI	62	3	93	7	53	1.755	9	5	2	25	41
MA	M	63	4	62	8	38	1.632	5	6	2	16	29
MC	M	63	7	90	6	46	1.957	9	5	4	23	41 <sup>2</sup>
MH	M	59, 60	4	85	9	45	1.889	6	5	2	21	34
MI	M	63	5	104	8	37	2.811	7	5	3	24	39
MP	M	63	6	77	6	47	1.638	7	4	3	20	34
MT	M	62, 63	3	98	8	53	1.849	6	5	2	25	38
NB	HI	57	8	66	10	43	1.535	10	6	4	20	40
NC	M	61, 62	6	65	5	31	2.097	6	2	1	14	23

<sup>1</sup> BI, Bay Islands; HI, Hog Island; M, Nash Farm; 1-8, mainland, within 8 miles of the study area.

<sup>2</sup> One phrase, counted here as an I phrase, appeared as an introductory phrase in one pattern, and later in the song in another pattern.

<sup>3</sup> One phrase, counted here as an I phrase, was used as an introductory phrase in one pattern, and as a trill phrase in another pattern.

<sup>4</sup> Three different phrases, counted here as I phrases, were used both as introductory phrases and later in the song; one of these appeared as an introductory phrase and a final phrase in the same song (I<sup>8</sup>, Fig. 2); the other two appeared as an introductory phrase in one pattern and later in the song in another pattern.

<sup>5</sup> One phrase, counted here as a T phrase, appeared as a trill phrase in one pattern, and as a single phrase only in another pattern.

TABLE 7. (Continued)

Bird	Loca- tion <sup>1</sup>	Years recorded	No. of record- ings	No. of songs	No. of song pat- terns	No. of song varia- tions	Songs per vari- ation	No. of different phrases in vocabulary				
								I	T	Z	Other	Total
ND	M	57	3	54	9	29	1.862	8	4	2	21	35
NF	M	59, 60, 61	11	97	12	39	2.487	11	9	4	28	52
NG	M	63	5	88	8	44	2.000	9	5	3	22	39 <sup>6</sup>
NH	M	61, 62	8	101	8	51	1.980	7	5	4	24	40
NJ	M	63	4	48	6	30	1.600	9	4	4	22	39
NM	M	62	2	34	6	23	1.478	7	4	3	17	31
NR	M	62, 63	5	185	8	102	1.814	9	6	4	28	47
NU	M	63	1	49	6	34	1.441	6	5	2	19	32
NX	M	61, 63	2	89	10	44	2.023	12	6	2	21	41 <sup>2</sup>
PA	HI	60, 61, 62	9	84	7	35	2.400	8	5	6	22	41
PH	HI	55, 56, 57	45	285	14	156	1.827	12	7	4	25	48
PL	HI	58	6	60	6	45	1.333	7	2	3	19	31
PO	HI	60	8	86	8	45	1.911	6	5	3	19	33
PR	HI	59, 60, 62, 63	30	417	10	158	2.639	11	6	2	24	43 <sup>5</sup>
SC	HI	61, 62	8	128	11	82	1.561	10	8	4	21	43
SP	HI	57	2	52	8	27	1.926	8	6	3	19	36
SS	HI	62	2	82	8	44	1.864	9	6	3	21	39
WD	HI	57, 58, 59, 61	53	384	6	144	2.667	6	4	2	14	26
WH	HI	59	13	63	4	33	1.909	4	4	2	14	24
WT	HI	60, 61, 62	16	226	10	92	2.457	7	6	5	26	44

<sup>6</sup> One phrase, counted here as an I phrase, appeared later in the song in the same pattern in which it was used as an introductory phrase, and later in the song only in another pattern.

similar, differing principally in the character of the introductory phrases (Fig. 4, A and B); these were considered different patterns because they began with different introductory phrases. These songs sound almost the same in the field; only a very careful observer would notice the difference in the introductory phrases.

Space here does not permit a complete listing of all the 3,616 variations found in the 544 song patterns of the Maine birds, but the following types of variation within a pattern were found:

1. Variation in the number of introductory phrases (Fig. 2).
2. Variation in the type of introductory phrases (e.g., pattern FH-4. Fig. 2). In patterns beginning with two or three types of introductory phrases, some songs of the pattern lacked one of the phrase types, or (in rare instances) there was a variation in the sequence of the different introductory phrase types.
3. Variation in the occurrence of a trill beyond the introductory phrases. In 88 of the 544 patterns, some variations of the pattern contained a trill and others lacked it (Table 5).

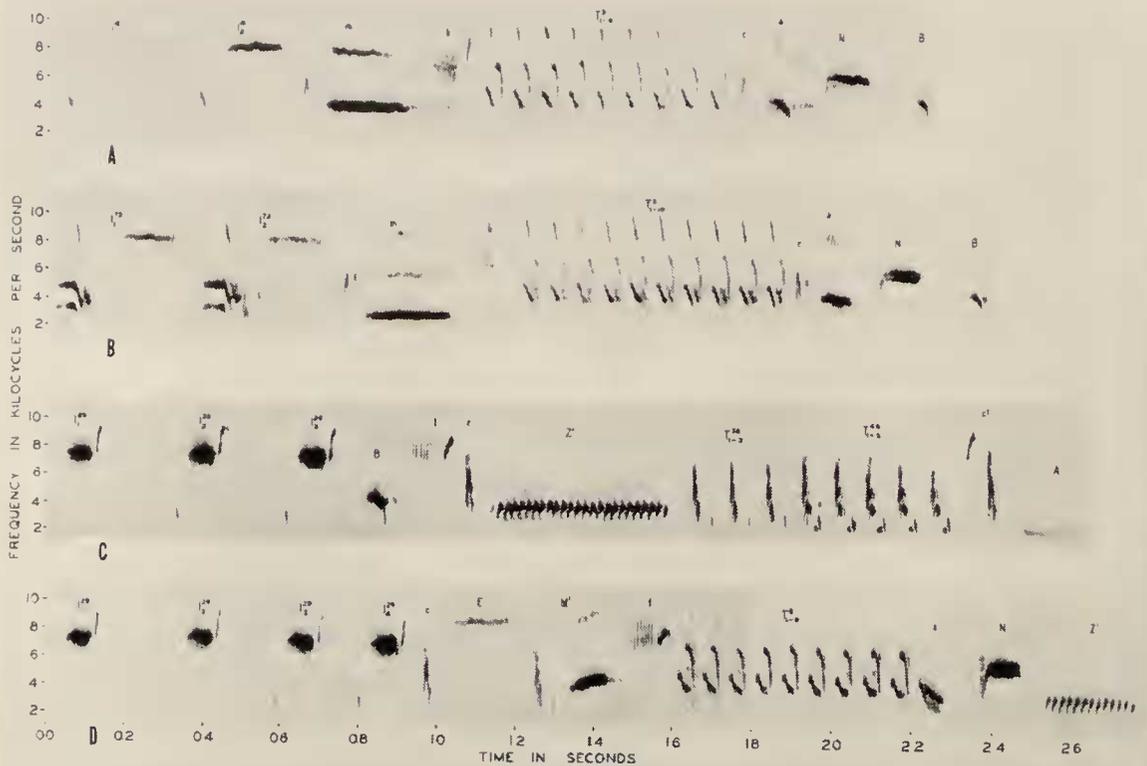


FIG. 4. Graphs illustrating the delimitation of song patterns. A, pattern BG-3A<sub>9</sub> (4260-5); B, pattern BG-5C<sub>10</sub> (4362-17); C, pattern FH-13A<sub>3-5</sub> (2054-13); D, pattern FH-2D<sub>9</sub> (2054-14). A and B differ only in the character of the introductory phrases and in the pitch of the low note in phrase *m*; they are designated as different patterns because of the differences in the introductory phrases. C and D are considered as different patterns, even though the introductory phrases are the same, because the remainder of the song is quite different in the two cases.

4. Variation in the number of trill phrases (Figs. 2 and 3).
5. Variation in the location of the trill in the song (when it was present); this type of variation occurred in 11 of the 544 patterns.
6. Variation in where, along a given sequence of phrases, the song ended. (An utterance was considered a song if it contained the first *two* phrases; a single introductory phrase, which a bird would occasionally utter, was not counted as a song.) This sort of variation was found in nearly every pattern.
7. Variation in the presence or absence of certain phrases (other than *T*) (Figs. 3 and 5).
8. Variation in the sequence of a few phrases (e.g., in pattern BA-1; see Fig. 5. C and D).
9. Variation in the number of phrases other than the introductory and trill phrases (Fig. 5, A and B).
10. Variation in the character of particular phrases. Such variation occurred chiefly in cases where the bird appeared to hesitate or falter at a par-

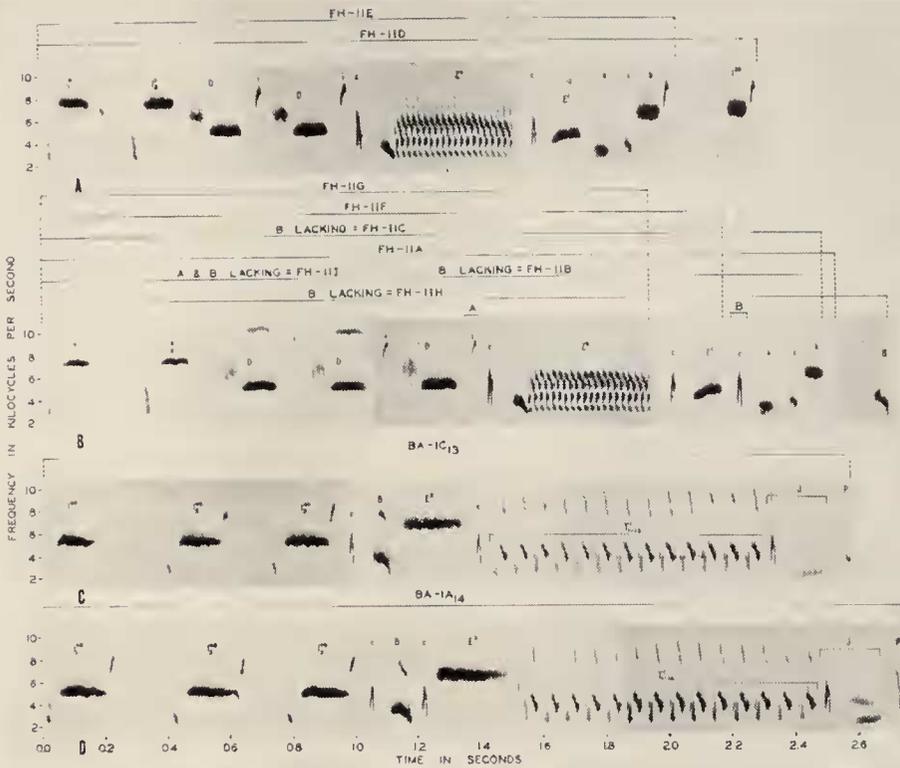


FIG. 5. A and B, variations in the songs of pattern FH-11; C and D, two variations of pattern BA-1 that differ in the sequence of two notes (*c* and  $E^2$ ). A, 1506B-15; B, 1486B-2 and 2179-1; C, 3504-1; D, 2826-2.

ticular phrase in occasional songs, and thus render the phrase a little different than usual; occasionally a phrase would be a little different in songs recorded at different times, or in different seasons (cf. Fig. 11, S and T, recorded the same season).

11. Variation in the ending of the song (Fig. 2).
12. Slight variations in note or phrase length.
13. Variations in the relative loudness of particular notes or phrases.

*Repertoires.*—Saunders (1951:107) gives the following data on the song repertoires of 13 birds:

1 bird	had	6	“different songs”
1 bird	had	8	“ ”
2 birds	had	9	“ ”
1 bird	had	11	“ ”
2 birds	had	12	“ ”
1 bird	had	15	“ ”
2 birds	had	16	“ ”
2 birds	had	18	“ ”
1 bird	had	24	“ ”

Wheeler and Nichols (1924) give 19 as the maximum number of songs from one bird, and Mrs. Nice (1943) mentions ten birds with 7 to 10 songs, four with 9 songs, eight with 10 to 12 songs, one with 13 songs, and one with 17 songs. Mulligan (1963) found 10 to 23 (average, 15.8) "song types" in 13 "rather well-studied" birds.

Table 7 gives data on the vocal repertoires of 53 birds for which the most data (6,558 songs, 426 patterns, 3,205 variations) were available. Since 50 songs (fewer in some of these 53 birds) are inadequate to determine a bird's repertoire, the figures presented represent only a minimum estimate of each bird's repertoire. The repertoires of these birds varied from 5 to 14 song patterns (average, 8.04) and from 14 to 190 total variations (*different* songs) (average, 60.5) per bird. One bird had 14 patterns, two had 13, two had 12, and two had 11. If the averages are calculated from the 20 birds represented in the recordings by 100 or more songs, they are 9.25 patterns and 99.0 different songs per bird; if they are calculated from the 10 birds represented by 200 or more songs, they are 9.9 patterns and 132.3 different songs per bird.

The number of songs per variation in these 53 birds varied from 1.270 to 3.242. The number of songs per variation in the ten birds represented by 200 or more songs are of interest:

FH (462 songs) . . . . .	2.432
PR (417 songs) . . . . .	2.639
BD (404 songs) . . . . .	2.675
WD (384 songs) . . . . .	2.667
PH (285 songs) . . . . .	1.827
CB (269 songs) . . . . .	3.241
IS (251 songs) . . . . .	2.303
WT (226 songs) . . . . .	2.457
BA (202 songs) . . . . .	1.472
IN (201 songs) . . . . .	3.242

These figures indicate that the songs of some birds were more variable than those of other birds (e.g., the songs of PH and BA were more variable than those of CB and IN), but they do not indicate an upper limit of the variability.

Table 8 shows the variability in the 47 patterns that showed 20 or more variations, or were represented by 40 or more songs; the variability in these patterns ranged from 7.000 to 1.212 songs per variation. Most of the patterns with the least variability (e.g., BD-3, PR-8, and IN-1) were patterns without a trill. Patterns that lacked a trill and still showed considerable variability (e.g., DC-1 and FG-2) were of Type 2, in which the number of introductory phrases was subject to greater variation than in songs of Type 1. Variations in the number of trill phrases account for a large part of the variation within a pattern.

The two patterns represented by the most songs (WD-2 and WD-3) were

TABLE 8  
SONG VARIABILITY IN PATTERNS REPRESENTED BY 40 OR MORE SONGS  
OR BY 20 OR MORE VARIATIONS

Song pattern	Pattern type	Trill*	No. of songs	No. of variations	Songs per variation
BA-1	1	±	40	33	1.212
BA-2	1	±	29	22	1.318
BA-4	1	+	47	32	1.469
BA-6	2	±	64	34	1.883
BD-1	1	±	66	38	1.737
BD-2	1	+	43	24	1.792
BD-3	1	0	77	11	7.000
BD-4	1	+	48	27	1.778
BD-7	1	±	80	21	3.810
CB-1	1	+	91	21	4.333
CB-4	1	±	49	14	3.500
DC-1	2	0	36	22	1.636
DC-3	1	±	31	21	1.476
DH-5	1	+	37	26	1.423
FA-5†	1	+	27	22	1.227
FG-2	2	0	30	22	1.364
FG-4	1	+	41	19	2.158
FH-1	1	+	45	7	6.429
FH-5	1	±	44	21	2.095
FH-6	1	±	41	20	2.050
FH-7	1	+	34	24	1.417
FH-10	1	±	49	15	3.267
FH-13**	1	±	27	20	1.350
FP-2	1	±	43	21	2.048
IN-1	2	0	52	9	5.778
IN-2	1	±	41	15	2.733
IN-3	1	+	51	12	4.250
IS-1	1	+	48	29	1.655
IS-5	2	+	39	23	1.696
NR-3	1	+	52	18	2.889
NR-8	1	+	36	28	1.286
PH-1	1	+	35	26	1.346
PH-2	1	±	48	28	1.714
PH-5	1	±	44	14	3.143
PR-1	1	±	59	17	3.471
PR-2	1	±	68	31	2.194
PR-3	1	±	58	15	3.867
PR-4	1	+	50	28	1.786
PR-5	1	±	54	19	2.842
PR-8	2	0	54	10	5.400

\* +, a trill present in all songs of the pattern; ±, a trill present in some songs of the pattern; 0, trill lacking.

† This pattern contained two trills.

\*\* When a trill was present, it contained phrases of two types.

TABLE 8 (*Continued*)

Song pattern	Pattern type	Trill*	No. of songs	No. of variations	Songs per variation
WD-1	1	±	64	22	2.909
WD-2	1	±	118	41	2.634
WD-3	1	+	94	38	2.474
WD-5	1	+	43	14	3.071
WD-6	1	±	51	20	2.550
WT-1	1	+	35	20	1.750
WT-4	1	±	42	14	3.000
Average			50.11	21.87	2.291

also the patterns represented by the most variations (Table 8). Apparently, the more songs of a pattern (or a bird) one examines, the more variations he will find. There is probably an upper limit to the number of variations in the songs of a given pattern (or bird), but it is difficult from the data here presented to determine what this limit is. Some patterns were subject to a greater amount of variation than others, depending (at least in part) on whether or not they contained a trill.

Since each Maine bird had, on the average, between 9 and 10 song patterns, and each pattern had an average of a little over 20 variations, it seems likely that we could expect each bird to have a repertoire of about 200 *different* songs: the nearest to this of any bird recorded was FH (represented by 462 songs), with 190 different songs. One would probably have to examine 500 or more songs of a bird to find 200 or more variations.

To compare the repertoires of the Maine birds studied with those of birds mentioned by Wheeler and Nichols (1924), Nice (1943), Saunders (1951), and Mulligan (1963), it is necessary to speak of song *patterns* rather than of *different* songs. The number of patterns in the Maine birds is lower than that mentioned by these writers; this may indicate less versatility in the birds studied, or it may be that some of the variations I have included in a single pattern would be recognized as "different songs" or different "song types" by these writers.

*Song pattern preferences.*—It has been stated (Nice, 1943:121–122) that a Song Sparrow usually goes through its whole repertoire before repeating any one song pattern, but it has been noted (Saunders, 1924; Nice, 1943) that a bird will often sing some of its songs more than others. Table 9 contains data on the song pattern preferences—as shown by the incidence of different patterns in the recordings studied—of the 12 Maine birds that had ten or more song patterns. Instances where a particular pattern appears only a very few times compared with the incidence of other patterns might represent songs by

TABLE 9  
DATA ON THE SONG PATTERN PREFERENCES OF SOME MAINE BIRDS

Song pattern number	Bird											
	PH	CB	FH	CL	NF	FA	SC	BD	NB	NX‡	PR	WT
1	35	91	45	14	28	6	31	65	4	2	59	35
2	48	20	24	24	17	11	3†	43	3	4	68	19
3	23	37	34	2†	21	19	12	77	3	16	58	29
4	19	49	39	7	2†	3†	13	48	3	16	50	42
5	44	28	44	3†	2†	27	25	51	15	9	54	29
6	27	23	41	2†	13	17	14	1*	6	14	25	22
7	14	7*	34	13	6*	7	7	80	7	9	26	13
8	21	3*	28	3†	1†	8	4*	4	3	10	54	13
9	7†	4*	30	6	3†	2†	5	8	3	5	19	20
10	34	2†	49	3†	1†	1†	5	27	19	4	4†	4†
11	1†	1†	29	9	2†	15	9					
12	4†	2†	38	8	1†							
13	6†	2†	27									
14	2†											
Total songs	285	269	462	94	97	116	128	404	66	89	417	226
Total variations	156	83	190	74	39	71	82	151	43	44	158	92

‡ One of the recordings studied contained all these patterns.

\* In one or more recordings containing this pattern only; this pattern *could* have been sung by a different bird.

† A pattern unquestionably by this bird; it was in one or more recordings with one or more other patterns.

a different bird, but this possibility has been ruled out in most of the cases shown in Table 9. It is apparent that a bird will sing some of its song patterns much more frequently than others, and some patterns (e.g., PH-11, which appeared only once in 285 songs, and PR-10, which appeared only four times in 417 songs) are sung only very rarely.

Thirty of the Maine birds were recorded in two or more seasons: 16 in two seasons, 8 in three seasons, 5 in four seasons, and 1 in six seasons; 26 of these birds are included in Table 7. Table 10 contains data on the song patterns sung by nine of these birds each year they were recorded. In only one of these cases (FH) was each of the bird's song patterns recorded each year; in the other cases there were one or more years in which certain patterns were not recorded. The presence of a given pattern in different years indicates that it is fixed: once a song pattern is developed by a Song Sparrow, it remains in the bird's repertoire the rest of its life. The absence of some patterns from the recordings of a bird in certain years is probably the result of a change in the song preferences of the bird, and/or not enough songs were recorded to secure the bird's complete repertoire. In at least some cases (e.g., patterns 5, 9, 11,

TABLE 10  
DATA ON THE VARIATIONS IN SONG PATTERN PREFERENCE IN DIFFERENT YEARS  
IN SOME MAINE BIRDS

Year	Number of songs of song pattern														Total songs
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Bird BA															
1957	8	11	4	15	4	14	8	—	—						64
1958	11	5	—	11	5	—	3	10	9						54
1959	21	13	13	21	10	50	—	—	17						145
Total	40	29	17	47	19	64	11	10	26						263
Bird BD															
1956	9	—	—	—	—	—	—	—	—	—					9
1958	19	19	11	21	24	1	3	—	—	—					98
1959	7	2	—	—	—	—	28	4	—	—					41
1960	17	6	34	16	10	—	24	—	1	8					116
1961	11	16	23	5	15	—	13	—	2	6					91
1962	2	—	9	6	2	—	12	—	5	13					49
Total	65	43	77	48	51	1	80	4	8	27					404
Bird CB															
1959	40	17	24	26	17	11	—	—	2	—	—	—	—		137
1960	2	2	6	—	—	4	7	3	—	—	—	—	—		24
1961	—	—	—	2	—	8	—	—	2	—	—	—	—		12
1962	49	1	7	21	11	—	—	—	—	2	1	2	2		96
Total	91	20	37	49	28	23	7	3	4	2	1	2	2		269
Bird FH															
1955	13	6	20	15	7	13	16	10	7	17	7	5	5		141
1956	32	18	14	24	37	28	18	18	23	32	22	33	22		321
Total	45	24	34	39	44	41	34	28	30	49	29	38	37		462
Bird IN															
1955	—	—	7	14	—	—									21
1956	44	40	25	16	14	4									143
1957	8	1	19	2	7	—									37
Total	52	41	51	32	21	4									201
Bird IS															
1958	4	8	—	—	—	—	—	—							12
1960	33	—	28	15	22	17	11	—							126
1961	—	—	—	—	6	—	10	—							16
1962	11	—	10	13	11	14	12	26							97
Total	48	8	38	28	39	31	33	26							251

TABLE 10 (Continued)

Year	Number of songs of song pattern														Total songs
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Bird PH															
1955	9	—	—	—	—	—	—	—	—	—	—	—	—	—	9
1956	22	48	19	16	44	19	4	20	5	13	1	—	—	—	211
1957	4	—	4	3	—	8	10	1	2	21	—	4	6	2	65
Total	35	48	23	19	44	27	14	21	7	34	1	4	6	2	285
Bird PR															
1959	12	14	9	2	5	—	—	—	—	—	—	—	—	—	42
1960	25	8	12	3	—	6	1	—	—	—	—	—	—	—	55
1962	16	42	33	34	39	11	19	54	13	—	—	—	—	—	261
1963	6	4	4	11	10	8	6	—	6	4	—	—	—	—	59
Total	59	68	58	50	54	25	26	54	19	4	—	—	—	—	417
Bird WD															
1957	7	44	33	7	15	6	—	—	—	—	—	—	—	—	112
1958	1	28	16	1	14	8	—	—	—	—	—	—	—	—	68
1959	39	26	19	6	4	11	—	—	—	—	—	—	—	—	105
1961	17	20	26	—	10	26	—	—	—	—	—	—	—	—	99
Total	64	118	94	14	43	51	—	—	—	—	—	—	—	—	384

12, and 13 of FH), a bird's song pattern preferences may change from one year to another. On the other hand, one or more of a bird's patterns may be very uncommon each year (e.g., WD-4).

*Constancy of song patterns.*—In the majority of the 30 birds recorded more than one season, the songs of a given pattern were essentially similar from one year to the next; it was by this similarity that individual birds were identified. The song patterns of a Song Sparrow are remarkably fixed.

The principal differences in a song pattern from one year to the next were in the particular variations that appeared. In most cases some pattern variations were recorded one year but not in other years; FA represents an extreme in this respect, as all but 3 of its 71 song variations were recorded only one season.

A few birds showed minor differences in particular patterns from one year to another—in the presence or absence of certain notes or phrases, or in the character of certain notes or phrases. All 10 songs of FH-8 in 1955 (Table 10) had the trill immediately following the introductory phrases ( $I^{20} T^3 \dots$ ), while in 1956 all 18 songs of this pattern had an extra note between the introductory phrases and the trill ( $I^{20} B T^3 \dots$ ). Variations involving the presence or absence of certain notes or phrases were not unusual, and some-

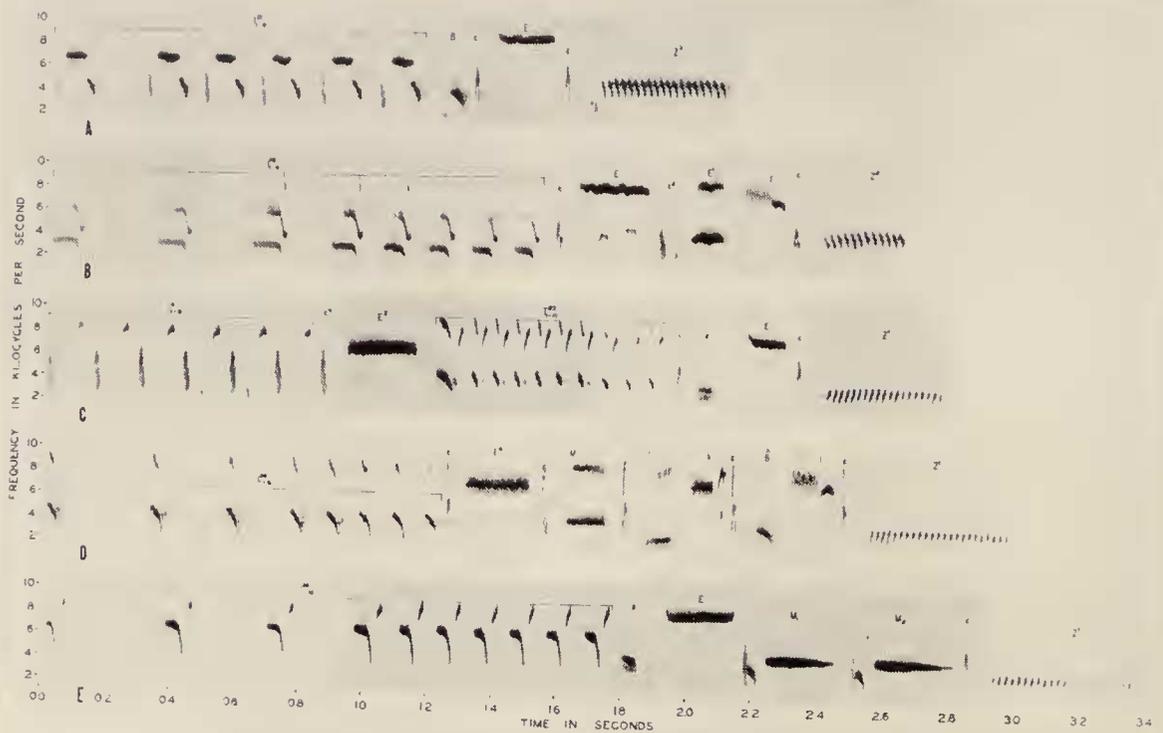


FIG. 6. Type 2 songs. A, WT-8C<sub>6</sub> (6067-45); B, PH-6C<sub>8</sub> (2858-2); C, IS-5C<sub>6, 10</sub> (4898-3); D, BN-3B<sub>8</sub> (5347-11); E, FP-1A<sub>10</sub> (6030-1). C is a Type 2 song containing a trill ( $T^{22}$ ) following the introductory phrases.

times occurred in a single recording. There were a few patterns in which a particular note or phrase differed slightly in character in different years; such differences were relatively uncommon in a single season or recording. The songs of pattern BD-4 began with a single type of introductory phrase in 1958, but in 1960-62 began with two types (one the same type that was in the 1958 songs). One note of the introductory phrases of pattern CL-8 was longer in 1960 than in 1962. Several other similar variations from year to year might be mentioned, but all were minor, and most of them would not be apparent in the field. The outstanding feature of a Song Sparrow's song patterns is their constancy from year to year.

#### IDENTICAL SONGS OR SONG PATTERNS BY DIFFERENT BIRDS

The literature is somewhat contradictory on the question of whether or not different Song Sparrows may sing identical songs or song patterns. Saunders (1951:99) states that in his 884 song records of this species there was no case of two birds with identical songs. Mrs. Nice (1943:138) reports cases of certain songs from a number of birds, and mentions one (song J from bird 4M) as having been heard from at least 22 birds. Mulligan (1963) found a few cases of two birds, usually close neighbors, singing songs of the same

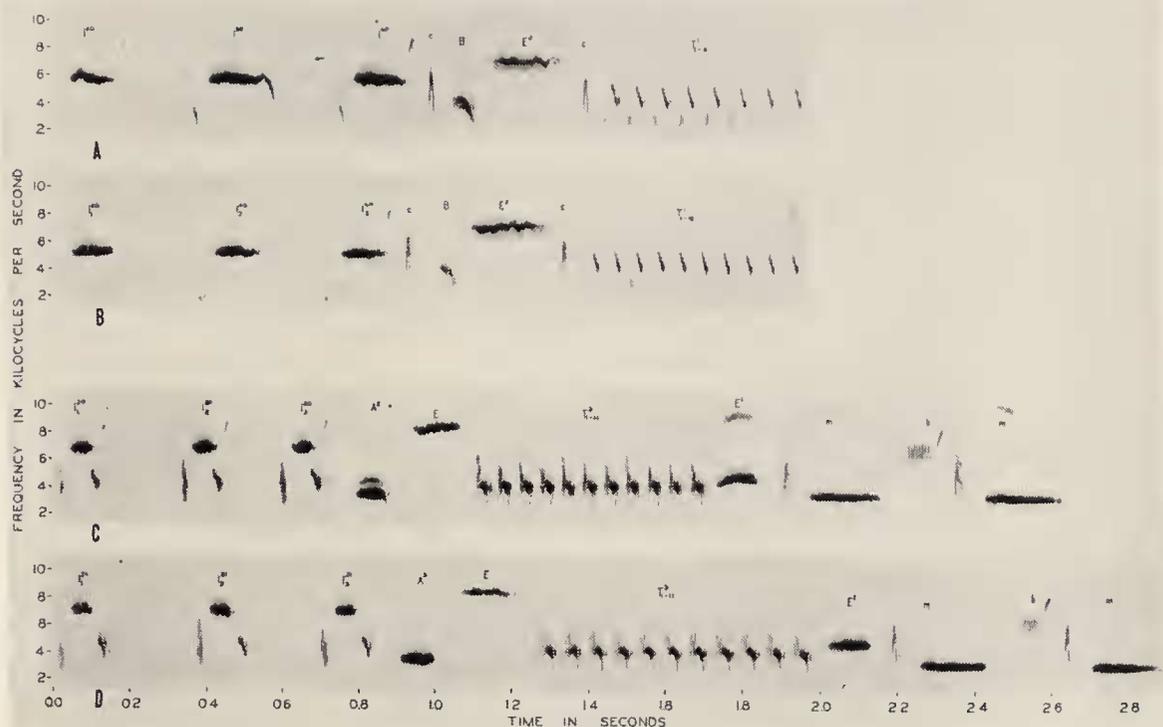


FIG. 7. Cases of songs by different birds that are nearly but not quite identical. A, BA-1R<sub>8</sub> (3504-9); B, PH-8A<sub>10</sub> (2175-3); C, PH-9C<sub>11</sub> (2822-3); D, SP-2A<sub>11</sub> (2970-5). A and B are identical except for the difference in the second introductory phrase and the length of the trill; only a very careful listener would notice these differences in the field. C and D are identical except that the introductory phrases in D are three-noted, and lack the final high note present in the  $I^{20}$  phrases of C, and the note following the introductory phrases ( $A^2$  in C and  $A^3$  in D) is a little different; these differences are not apparent in the field.

“song types.” The situation in the Maine birds studied was similar to that found by Mulligan.

Two songs by different birds may sound alike to the ear, but may actually be different as shown by the graphs; a number of instances of this sort were found in the Maine songs, two of which are illustrated in Fig. 7. Such differences may be due to the presence or absence of very short notes, differences in the number of trill phrases, or slight differences in the character of individual notes.

Song Sparrow songs by different birds are considered identical if they can be represented by the same letter formula, but determining whether or not song patterns by different birds are identical is not as simple. If identical songs by different birds are relatively complete, they are assumed to represent the same pattern: if they are short songs, they may or may not represent the same pattern, and to determine if the patterns are identical it is necessary to examine the longer songs of these birds (if available). It is also possible

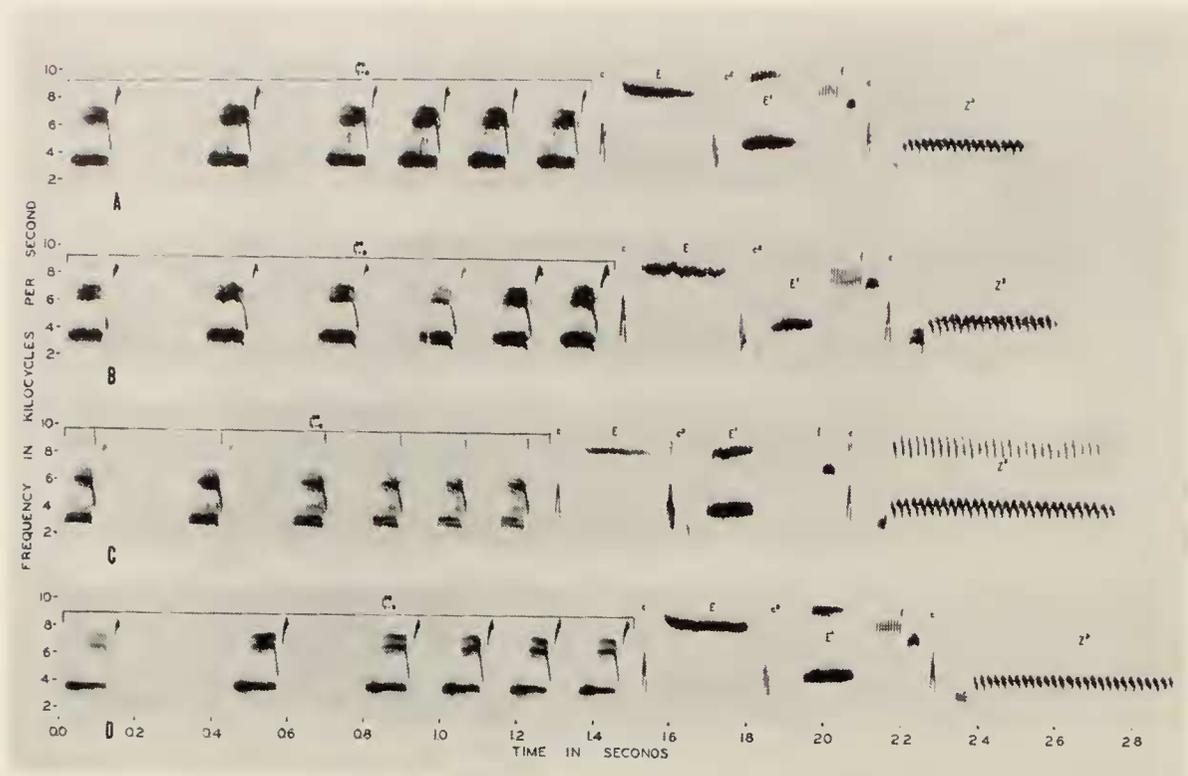


FIG. 8. Identical songs by four different birds:  $I_0^{10} c E c' E' f c Z^3$ . A, SS-7A<sub>6</sub> (6101-62); B, SQ-1B<sub>6</sub> (5477-1); C, BA-5B<sub>6</sub> (4308-46); D, IV-2F<sub>6</sub> (6113-18).

that two birds might sing songs of the same pattern that were not identical, but represented different variations of that pattern.

Thirteen cases of identical songs by different birds were found in the Maine songs: one involved a bird in the study area (DC) and another (FR) 6½ miles away, and the other 12 involved birds in the study area. Seven cases involved birds on Hog Island: one (Fig. 8) involved four birds, another (Fig. 9 A-C) involved three birds, and the rest involved two birds. The territories of most of these Hog Island birds were separated by 100 yards or more, or the birds were present in different years. Three cases involved birds on the Farm; one of these (Fig. 10 A-C) involved three birds, and the other two involved two birds (one of these is shown in Fig. 10 D-E); most of these Farm birds either had adjacent territories, or were present in different years. Two cases (one of which is shown by Figs. 6 E and 9 D) involved a bird on the Farm and another on Hog Island, from ¼ to ½ mile apart and recorded in different years.

One of the 13 cases of identical songs by different birds was the following:

$I_{10}^{26} a c E^2 M$  ..... DC-1E<sub>10</sub> and FR-1C<sub>10</sub>

The longer songs of DC-1 and FR-1 were different:

$I_{10}^{26} a c E^2 M_2 c Z^1 x F E^3 N B$  ..... DC-1D

$I_{10}^{26} a c E^2 M_2 T_1^5 b c E A^2 f$  ..... FR-1A

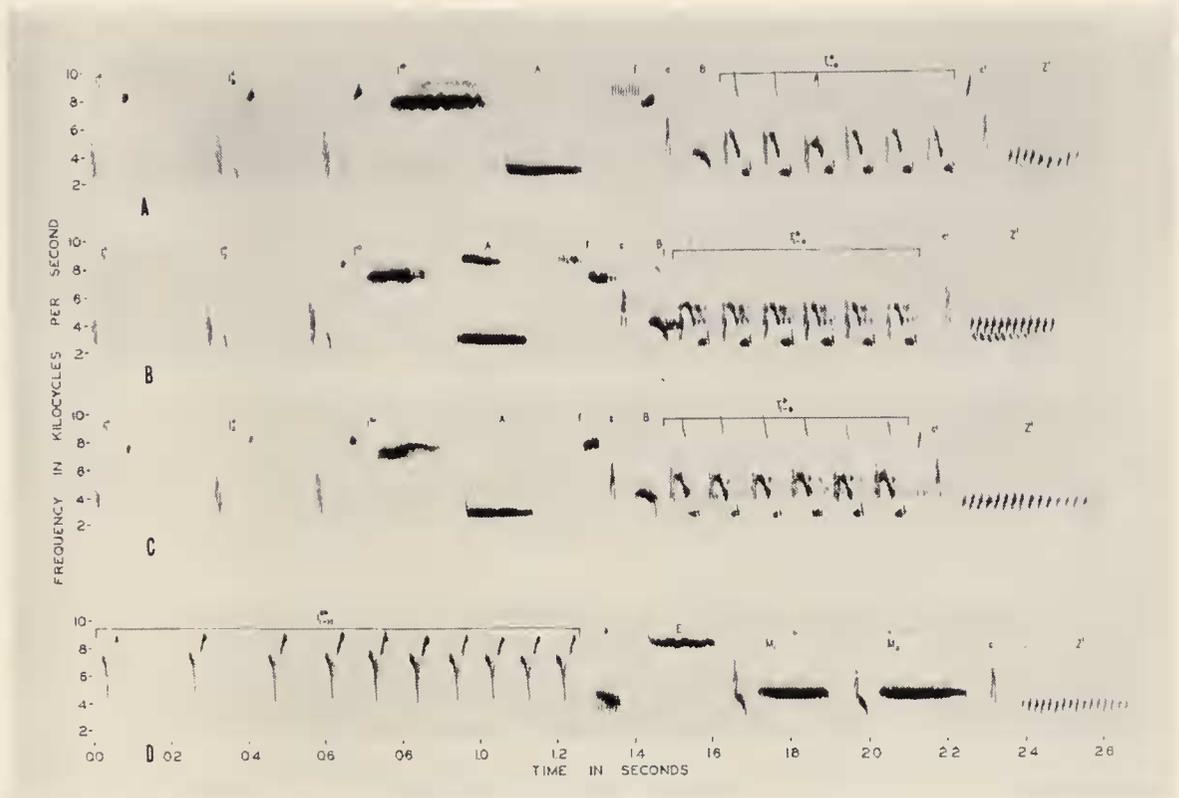


FIG. 9. A, B, and C, identical songs by different birds:  $I_2^1 I_{10}^0 A f c B T_6^0 c^1 Z^1$ ; A, BD-7A (5395-13) ( $T_3$  and  $Z^1$  slightly distorted); B, PR-3A<sub>0</sub> (6037-1); C, WB-1A<sub>6</sub> (3501-4). D, a song by ND identical to one by FP:  $I_{10}^{20} a E M_2 c Z^1$ ; ND-4A<sub>10</sub> (2994-9); identical to FP-1A<sub>10</sub> (Fig. 6 E).

Since the phrases beyond the  $M$  phrases in the longer songs of DC-1 and FR-1 were different, the patterns were considered different. Similarly, three other cases, of the 13 mentioned above, were considered to represent different patterns. Three cases were found in the Maine songs of two birds singing what were considered identical *patterns*, though identical *songs* were not recorded from the two birds of each pair.

Twelve instances were found in the Maine songs of what was considered the same *song pattern* sung by different birds; in nine of these cases there were identical *songs* by the different birds, and in the other three cases the songs of the different birds were considered different variations of the same pattern. Seven of the 12 instances involved birds on Hog Island whose territories were fairly well separated, or the birds were present in different years (or both). Four instances involved birds on the Farm whose territories were either adjacent, separated by 100 yards or more, or the birds were present in different years. One case involved a bird on Hog Island and another on the Farm,  $\frac{1}{2}$  mile apart and recorded in different years.

In practically all the cases of identical songs or song patterns sung by different birds, the birds involved were members of what may be considered the

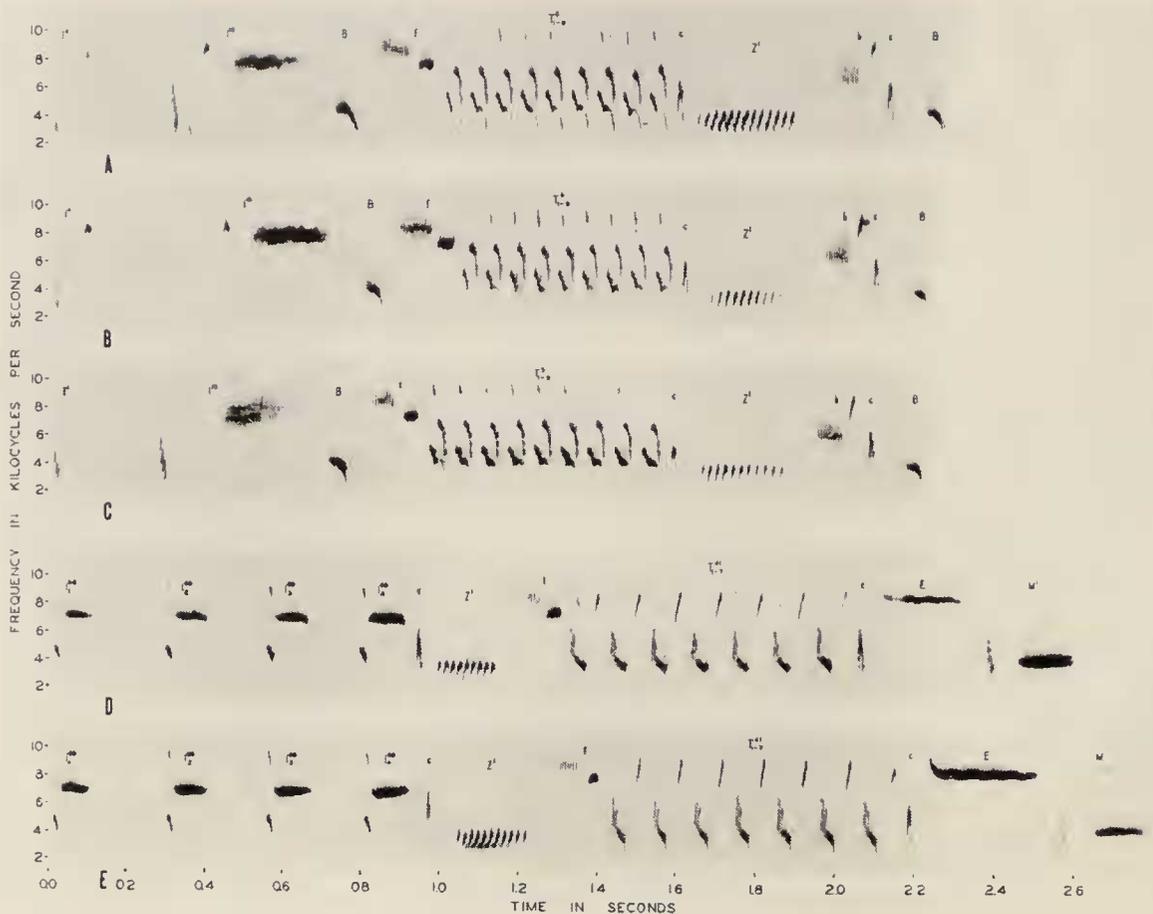


FIG. 10. Two cases of identical songs by different birds. A, B, and C,  $I^1 F^{13} B j T_9^5 c Z^1 b c B$ ; A, MO-1B<sub>9</sub> (4842-3); B, NC-5A<sub>9</sub> (5371-11); C, NR-3A<sub>9</sub> (6120-6). D and E,  $I_4^{08} c Z^1 j T_7^{41} c E M^1$ ; D, NG-6A<sub>7</sub> (6483-43); E, NM-5A<sub>7</sub> (6089-25).

same population (birds on the study area); in only one case (DC-1E<sub>10</sub> = FR-1C<sub>10</sub>) were the birds involved very far apart (about 6½ miles), and this case involved identical short songs of different song patterns. It is likely that the only cases of two or more Song Sparrows singing the same songs or song patterns will be birds in the same general area.

#### SUMMARY

This study is based on an analysis by means of a sound spectrograph of 7,212 tape-recorded songs, of 120 birds; 6,645 of these songs, of 77 birds, were recorded in a 40-acre study area in Muscongus Bay, Lincoln Co., Maine; the rest were recorded elsewhere in Maine, at distances of ½ to 112 miles from the study area. The recordings were made over a period of 11 years, 1953-63.

Most songs began with two or more similar phrases; the remaining phrases varied considerably in different songs. The songs of a given bird that began with the same type(s) of introductory phrases, followed by approximately the same sequence of other phrases, were said to represent a given song pattern. The songs contained both musical and nonmusical notes; the musical notes were 0.04 to 0.25 second in length (rarely longer),

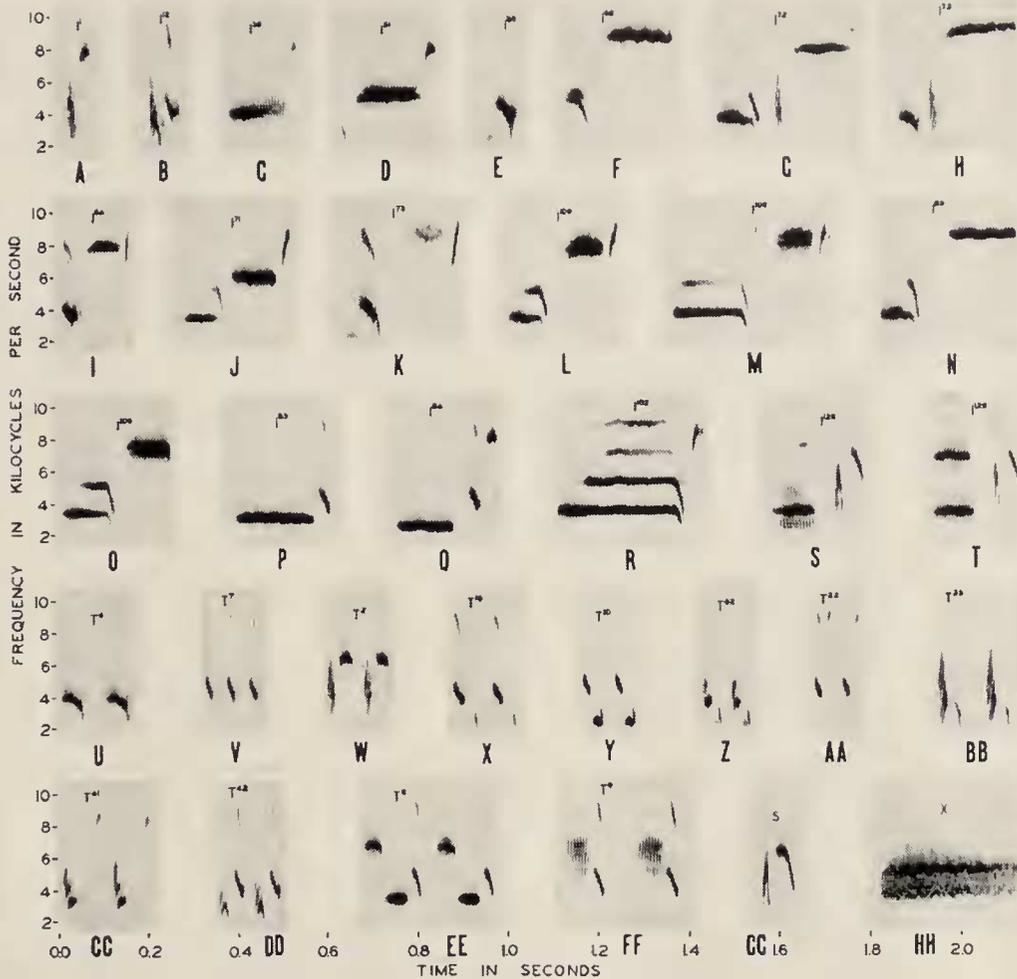


FIG. 11. A-T, introductory phrases; U-FF, trill phrases; GG and HH, other phrases. A,  $I^1$  (2994-2, ND-6); B,  $I^{12}$  (6482-2, NG-3); C,  $I^{30}$  (4757-3, MH-9); D,  $I^{51}$  (4886-11, IS-3); E,  $I^{65}$  (2994-17, ND-8); F,  $I^{68}$  (5458-2, SC-4); G,  $I^{72}$  (6035-1, DH-1); H,  $I^{72}$  (6523-22, MI-3); I,  $I^{64}$  (4343-3, BT-8); J,  $I^{71}$  (4891-1, CB-7); K,  $I^{73}$  (3674-2, MB-4); L,  $I^{103}$  (2970-32, SP-7); M,  $I^{109}$  (6512-7, FA-9); N,  $I^{69}$  (6109-4, CB-11); O,  $I^{106}$  (5958-1, IS-7); P,  $I^{83}$  (4220-1, BT-3); Q,  $I^{84}$  (3665-28, BD-4); R,  $I^{102}$  (6531-43, MT-5); S,  $I^{120}$  (4332-1, CB-3); T,  $I^{120}$  (4250-18, CB-3); U, two  $T^1$  phrases (2830-14, BA-4); V, three  $T^7$  phrases (2970-15, SP-4); W, two  $T^2$  phrases (2830-2, BA-2); X, two  $T^{10}$  phrases (4199-3, CB-6); Y, two  $T^{10}$  phrases (2211-58, PH-6); Z, two  $T^{62}$  phrases (6089-1, NM-1); AA, two  $T^{22}$  phrases (2164-1, PH-5); BB, two  $T^{35}$  phrases (6523-37, MI-5); CC, two  $T^{11}$  phrases (2994-17, ND-8); DD, two  $T^{12}$  phrases (6505-1, MA-7); EE, two  $T^8$  phrases (6505-3, MP-1); FF, two  $T^9$  phrases (4250-17, CB-2); GG, an S phrase (6491-25, NG-4); HH, an X phrase (2994-17, ND-8).

and were usually steady in pitch; the nonmusical notes were either very short and abruptly slurred, or buzzy. The buzzes were of three principal types, with modulation frequencies of 42-100, 145-165, and 300-335 per second.

The introductory phrases contained from 1 to 5 (average, 2.45) notes, and varied in number from 1 to 20. The song patterns found were classified into two types on the basis

of the number and spacing of the introductory phrases: Type 1, with 1-5 (usually 2-4) relatively evenly spaced introductory phrases, and Type 2, with 5-20 phrases in which the first two or three were usually slower than the rest. There was an increase in the rate of the introductory phrases through the series in most songs, and in all songs the first introductory phrases averaged 1.15 times as long as the last ones. The first introductory phrases were uttered at rates of 1.96 to 7.69 (average, 2.98) per second, and were faster in Type 2 than in Type 1 songs; the final introductory phrases were uttered at rates of 1.56 to 12.50 (average, 3.42) per second, and were faster in Type 2 than in Type 1 songs.

The Maine songs studied contained 544 song patterns, of which 473 (86.95%) were of Type 1, and the remainder of Type 2. A trill (a series of similar phrases uttered at rates of 6 to 25 per second) occurred beyond the introductory phrases in at least some songs of 410 patterns (75.37%), 387 (81.82%) of Type 1 and 23 (32.39%) of Type 2; 15 patterns contained two trills, and in 2 patterns the trill consisted of two slightly different phrase types. The number of phrases in the trills varied from 0 (pattern variations lacking the trill) to 26; the average maximum number was  $9.40 \pm 0.14$ . In 76 patterns the trill was immediately following the introductory phrases, in 167 it was 1-3 phrases after the trill, and in 178 patterns it was later in the song; in 11 patterns its location varied in different variations of the pattern.

Buzzes termed Z buzzes, with modulation frequencies of 42-100 per second, and usually 0.25 to 0.50 second in length, occurred in 412 (75.74%) of the Maine patterns; their location, when present, varied.

A Song Sparrow starting a song may stop anywhere along a given sequence, even after the first phrase, but most songs were at least 2 seconds in length, and the majority were 2.5 to 3.0 seconds in length; a few were as long as 4.0 seconds. The normal singing rate averaged  $5.2 \pm 0.1$  songs per minute; when a bird was stimulated by playbacks, its singing rate averaged  $8.2 \pm 0.1$  songs per minute.

Most of the phrases in the songs of the birds in the study area occurred in the songs of different birds. For 25 of the most common phrases of the study area birds, the incidence was less outside the study area than in it, and in general the farther away from the study area one goes, the less common the phrase was. The Song Sparrow thus exhibits what might be termed local dialects, suggesting that the various phrases of the song are learned by listening to other birds.

The birds that were represented in the recordings by a substantial number of songs had vocabularies of from 26 to 51 phrases, and averaged about 40. These were variously combined to produce a number of different song patterns. The following variations were found in the songs of a given pattern: (1) the number of introductory phrases, (2) the type of introductory phrases, (3) the occurrence of a trill beyond the introductory phrases, (4) the number of trill phrases, (5) the location of the trill in the song, (6) where, along a given sequence of phrases, the song ended, (7) the presence or absence of certain phrases other than trill phrases, (8) the sequence of a few phrases, (9) the number of phrases other than introductory and trill phrases, (10) the character of individual phrases, (11) the ending of the song, (12) the length of some notes, and (13) the relative loudness of particular notes.

The repertoires of the birds studied varied up to 14 patterns; one bird had 14 patterns, two had 13, two had 12, and two had 11. In 53 birds represented by at least 50 songs or 6 song patterns, the repertoires ranged from 5 to 14 song patterns (average, 8.04) and 14 to 190 total variations (*different* songs) (average, 60.5). In ten birds represented

by 200 or more songs, the repertoires averaged 9.9 song patterns and 132.3 different songs per bird.

Thirty of the Maine birds were recorded in two or more years (one was recorded in 6 years), and these birds' song patterns were remarkably constant from year to year. Once a song pattern is developed by a bird, it remains in the bird's repertoire the rest of its life. Some patterns are sung relatively rarely.

Thirteen cases were found in the recordings studied of identical songs by different birds: one by four birds, two by three birds, and the rest by two birds. Four of these appeared to be instances of short variations of different patterns; the other nine appeared to be instances of identical song patterns. Three other instances were found of what appeared to be songs of the same pattern sung by two different birds, but the particular variations in each instance were different. Most of the cases of different birds with identical songs or song patterns were of birds relatively close together (on the study area); one case of identical songs by two birds involved birds about 6½ miles apart, and the songs appeared to be short variations of different patterns.

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